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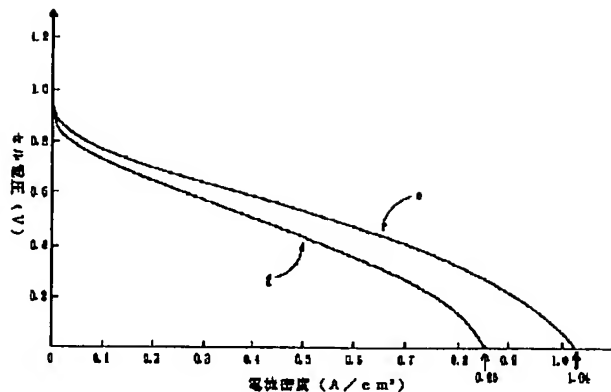
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APPLICANT : AQUEOUS RES:KK;

INVENTOR : KITA HIDEAKI;

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TITLE : PLATINUM-IRON ALLOY ELECTRODE  
CATALYST AND FUEL CELL



ABSTRACT : PROBLEM TO BE SOLVED: To develop a highly active electrode catalyst for a fuel cell by recognizing the problem that a divergent increase in overvoltage has a serious effect on the lowering of the cell voltage of the fuel cell and noticing an electrode catalyst supposed to be related to the concn. overvoltage.

SOLUTION: This electrode catalyst contains a tetragonal platinum-iron alloy. The tetragonal platinum-iron alloy is a platinum-iron alloy contg. preferably 25-75 atomic %, more preferably 40-60 atomic % or more preferably 45-55 atomic % iron. By using an electrode carrying the electrode catalyst to constitute a fuel cell, a decrease in the concn. overvoltage is suppressed even if the fuel cell is operated and the current density is increased, and hence the cell voltage of the cell is not decreased. The I-V characteristic in the fuel cell is shown in the figure, the curve (e) shows the characteristic when Pt/Fe atomic %=50/50, and the curve (f) shows the characteristic when platinum is 100%.

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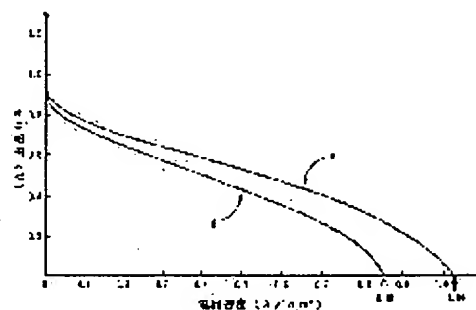
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KITA HIDEAKI

## (54) PLATINUM-IRON ALLOY ELECTRODE CATALYST AND FUEL CELL

(57)Abstract:

PROBLEM TO BE SOLVED: To develop a highly active electrode catalyst for a fuel cell by recognizing the problem that a divergent increase in overvoltage has a serious effect on the lowering of the cell voltage of the fuel cell and noticing an electrode catalyst supposed to be related to the concn. overvoltage.

SOLUTION: This electrode catalyst contains a tetragonal platinum-iron alloy. The tetragonal platinum-iron alloy is a platinum-iron alloy contg. preferably 25-75 atomic %, more preferably 40-60 atomic % or more preferably 45-55 atomic % iron. By using an electrode carrying the electrode catalyst to constitute a fuel cell, a decrease in the concn. overvoltage is suppressed even if the fuel cell is operated and the current density is increased, and hence the cell voltage of the cell is not decreased. The I-V characteristic in the fuel cell is shown in the figure, the curve (e) shows the characteristic when Pt/Fe atomic %=50/50, and the curve (f) shows the characteristic when platinum is 100%.



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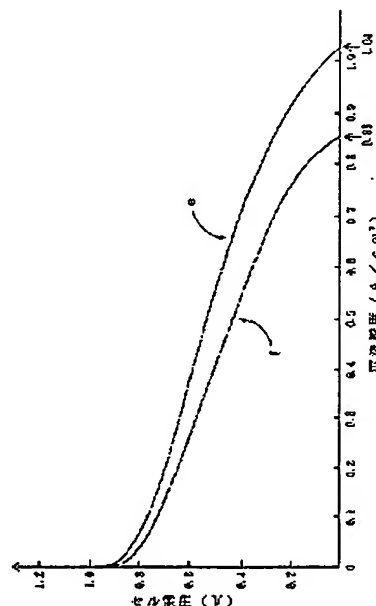
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(54) 【発明の名称】 白金-鉄合金電極触媒及び燃料電池

(57) 【要約】

【課題】 濃度過電圧  $\eta_c$  の発散的増大が、燃料電池のセル電圧の低下に大きな影響を与えるという問題点を認識し、濃度過電圧  $\eta_c$  と関連があると考えられる電極触媒に着目し、燃料電池用の高活性な電極触媒を開発し、電極触媒を担持した電極を用いた燃料電池を提供する。

【解決手段】 本発明の電極触媒は、正方晶の白金-鉄合金を包含することを特徴とする。正方晶の白金-鉄合金は、好ましくは25～75原子%、さらに好ましくは40～60原子%、最も好ましくは45～55原子%の鉄を含有する白金-鉄合金である。該電極触媒を担持した電極を用いて燃料電池とすることにより、燃料電池を運転しても、電流密度を上昇させても濃度過電圧  $\eta_c$  の減少を抑えることができ、したがって、燃料電池のセル電圧の減少を抑えることができる。図2は燃料電池におけるI-V特性を示し、図2中、曲線eは本発明のPt/F e原子% = 50/50の場合、曲線fは白金が100%の場合を示す。



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【特許請求の範囲】

【請求項1】 正方晶の白金-鉄合金を包含することを特徴とする電極触媒。

【請求項2】 25～75原子%の鉄を含有する白金-鉄合金を包含する請求項1記載の電極触媒。

【請求項3】 40～60原子%の鉄を含有する白金-鉄合金を包含する請求項1記載の電極触媒。

【請求項4】 45～55原子%の鉄を含有する白金-鉄合金を包含する請求項1記載の電極触媒。

【請求項5】 請求項1、2、3又は4記載の電極触媒を担持した電極を用いる燃料電池。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、各種電気分解或いは燃料電池の電極に使用される電極触媒及び該電極触媒を担持した電極を用いた燃料電池に関する。

【0002】

【従来の技術】燃料電池の電極には、燃料を酸化するための燃料極としての陰極及び供給された酸素を還元する空気極としての陽極があり、これらの各電極上での反応を促進し、燃料電池の性能を高めるために、電極触媒を各電極に担持させることが行われている。

【0003】燃料として水素、酸化剤として空気（酸素）を用いる燃料電池のI-V特性（電流密度に対する\*

$$\eta = \eta_a + \eta_r + \eta_o \quad (\text{式1})$$

$$\eta_a = a - b \times \log I \quad (\text{式2})$$

$$\eta_r = b \times \log \left(1 - \frac{I}{I_L}\right) \quad (\text{式3})$$

$$\eta_o = IR \quad (\text{式4})$$

【0006】上記各式において、a、bは定数、I<sub>L</sub>は限界電流密度と呼ばれる値で、反応物質又は反応生成物が反応のために移動できる限界値によって決まる定数である。この移動限界値は、通例、反応物質又は反応生成物が拡散によって移動するため、電極の構造（多孔性、厚さ等）や、物質の濃度などによって変わる。また、Rは抵抗である。

【0007】式（4）より判るように、電流密度Iが限界電流密度I<sub>L</sub>に近づくと、濃度過電圧η<sub>r</sub>は発散的に増大する。

【0008】

【発明が解決しようとする課題】本発明者らは、濃度過電圧η<sub>r</sub>の発散的増大が、燃料電池のセル電圧の低下に大きな影響を与えるという問題点を認識し、濃度過電圧η<sub>r</sub>と関連があると考えられる電極触媒に着目し、燃料電池用の高活性な電極触媒を開発し、該電極触媒を担持した電極を用いた燃料電池を提供することを目的とする。

【0009】

【課題を解決するための手段】上記した問題点に鑑み、

\*セル電圧）は、理論的には、一例として図1の曲線aに示すような約1.2Vを通り直線状の出力特性を有すると考えられるが、実際には次の（i）～（iii）の原因で、同図曲線bに示すように、電流密度の増加に従い大きく湾曲してセル電圧が低下し劣化する特性となっていることが既に知られている。その原因を大別すると、（i）電極上での反応物質（水素、酸素等）の反応速度に起因するものとして、図1において、曲線aと曲線cで挟まれる量で示される活性化過電圧η<sub>a</sub>による損失、（ii）電池の電解質等の内部抵抗に起因するものとして、図1において、曲線cと曲線dで挟まれる量で示される抵抗過電圧η<sub>r</sub>による損失、（iii）電極上での反応場（通気、電極に存在する触媒上）への反応物質又は反応生成物の移動のし易さに起因するものとして、図1において、曲線dと曲線bにより挟まれる量で示される濃度過電圧η<sub>r</sub>による損失、が挙げられる。

【0004】全過電圧をη、電流密度をIとした場合、活性化過電圧η<sub>a</sub>、抵抗過電圧η<sub>r</sub>、濃度過電圧η<sub>r</sub>の間には、次の式（1）～式（4）が成立することが既に報告されている（喜多他著「電気化学の基礎」技報堂出版発行、第200頁）。

【0005】

【数1】

本発明者らは、濃度過電圧の低下の原因と推測される酸素の触媒上への吸着を弱めることに着目し、種々の金属や合金材料の電極触媒への利用可能性について鋭意探索した結果、特定の結晶構造の白金-鉄合金が、濃度過電圧の増加の少ない燃料電池の電極触媒に好適であることを見だし、本発明に至った。

【0010】すなわち、本発明の電極触媒は、正方晶の白金-鉄合金を包含することを特徴とする。正方晶の白金-鉄合金は、好ましくは25～75原子%、さらに好ましくは40～60原子%、最も好ましくは45～55原子%の鉄を含有する白金-鉄合金であることが望ましい。鉄の原子%が25未満、或いは75を越えると、該白金-鉄合金を担持した電極を用いた燃料電池では、濃度過電圧の増加の影響が無視できず、燃料電池の性能上好ましくはない。

【0011】また、本発明の燃料電池は、上記特徴を有する電極触媒を担持した電極を用いることを特徴とする。

【0012】本発明の電極触媒は、白金-鉄合金の結晶の形態が正方晶であることが重要である。正方晶が崩れ

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ると、濃度過電圧 $\eta$ 、損失が原因のセル電圧が低下し、燃料電池の性能が低下し、好ましくない。

【0013】本発明の電極触媒による燃料電池における濃度過電圧 $\eta$ 、の低下の減少化効果は、恐らく、本発明の電極触媒に対する酸素の吸着力が従来の電極触媒に対する吸着力に比べて弱いために生ずるものであらうと考えられる。

【0014】本発明の電極触媒は、酸素の還元作用が行われる陽極のみならず、燃料極においても耐CO被毒触媒としての適用が可能である。

【0015】本発明の電極触媒は、電極材料に担持させて使用することができ、その電極触媒の担持方法は、例えば、カーボン等の電極材料からなる電極上に、触媒粉末を含むペーストを適用して触媒層を形成してもよい。

【0016】

【実施例】

【実施例1】テフロンディスパーション（ダイキン工業（株）製、D-1）により撥水化したポラスカーボンからなる電極上に、イオン交換樹脂分散液（ナフィオン溶液：アルドリッチ社製）及び触媒粉末よりなり、触媒成分の異なる2種類のペーストを印刷法にて適用して次の2種類の触媒層が形成された電極（空気極）を各々製造した。即ち、電極触媒としてPtのみからなり且つPt担持量が0.3mg/cm<sup>2</sup>の空気極と、電極触媒として原子比Pt/Feが50/50からなる正方晶のPt-Fe合金を適用しPt成分の担持量が0.3mg/cm<sup>2</sup>の空気極を得た。

【0017】一方、燃料極として、上記空気極と同様にして、Pt担持量が0.5mg/cm<sup>2</sup>の電極を製造した。

【0018】前記工程で得られた空気極と燃料極の間にナフィオン115膜（商品名：米国デュポン社製）を挟んで、ホットプレスすることにより、電極触媒の種類異なる2種の単電池（セル有効面積が20.25cm<sup>2</sup>、□45）を各々製造した。この各燃料電池の陰極に水素ガスを、陽極に空気を流し、電池温度70℃で運転して、電流密度に対するセル電圧を測定した。その結果を図2の電流密度-電圧特性のグラフに示す。図2中、曲線eは原子比Pt/Feが50/50、曲線fはPt100%の電極触媒を使用した場合をそれぞれ示す。

【0019】図2によれば、Pt100%のみのものよりも、原子比Pt/Feが50/50とした場合の方が、電流密度に対するセル電圧の降下が少ないことがわかる。そのため、例えば、燃料電池を0.6Vで定常動作させると、Pt100%のみのものよりも原子比Pt/Feが50/50とした場合の方が、約60%の出力

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増が見込めることがわかる。濃度過電圧の低減により、電圧効率も向上し、高効率な燃料電池とすることができ、また、Pt100%の電極触媒では燃料電池の限界電流密度が0.86A/cm<sup>2</sup>であったのに対し、本実施例1の原子比Pt/Fe=50/50の電極触媒では、1.04A/cm<sup>2</sup>まで達成することができた。

【0020】（実施例2）電極触媒として原子比Pt/Feが50/50、40/60、60/40の正方晶のPt-Fe合金を用いて、前記実施例1と同様な方法により、材質の異なる3種類の電極を製造し、さらに各々単電池を製造した。比較例として、Pt100%の電極触媒を用いて同様に単電池を製造した。

【0021】さらに、前記実施例1と同様な方法で各単電池について酸化剤を酸素とした場合の電流密度に対するセル電圧を測定した。そのセル電圧から濃度過電圧を求めた。その結果を図3の電流密度-濃度過電圧特性のグラフに示す。図3中、曲線g（○印）は原子比Pt/Feが50/50、曲線h（◇印）は60/40、曲線i（△印）は40/60の本発明の電極触媒を示し、□印は原子比Pt/Feが100/0の比較例の電極触媒を示す。

【0022】図3によれば、原子比Pt/Feが50/50とした場合が、最も電流密度に対するセル電圧の降下が少ないことがわかる。

【0023】

【発明の効果】本発明の電極触媒を用いた燃料電池は、濃度過電圧の低下が原因の出力の低下を抑制することができる。

【0024】本発明の電極触媒は、濃度過電圧の低減効果を有するので、該電極触媒を用いた燃料電池は、燃料極及び空気極のいずれにおいてもそれらの反応ガスである水素、酸素の利用率が向上し、供給ガス中のこれらの反応ガス分圧が低い場合でも充分な出力を生ずる。

【図面の簡単な説明】

【図1】従来の、燃料として水素、酸化剤として空気（酸素）を用いる燃料電池のI-V特性（電流密度に対するセル電圧）の一例を示すグラフである。

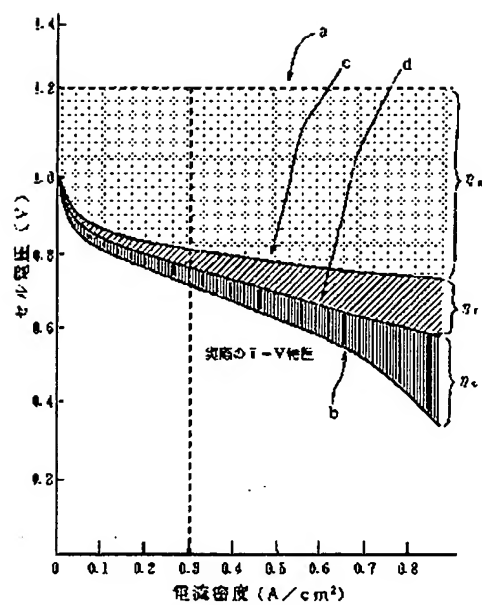
【図2】Pt100%の電極触媒を担持した電極を用いる燃料電池と、原子比Pt/Fe=50/50の正方晶のPt-Fe合金を電極触媒として担持した電極を用いた燃料電池による電流密度に対するセル電圧を示すグラフである。

【図3】原子比Pt/Fe=50/50、40/60、60/40の各正方晶のPt-Fe合金、及びPt/Fe=100/0を電極触媒として担持した各電極を用いた燃料電池による電流密度に対する濃度過電圧の特性を示すグラフである。

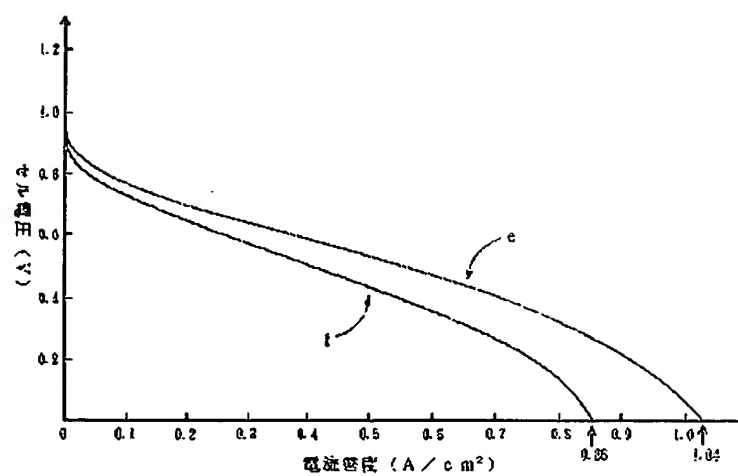
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【図1】



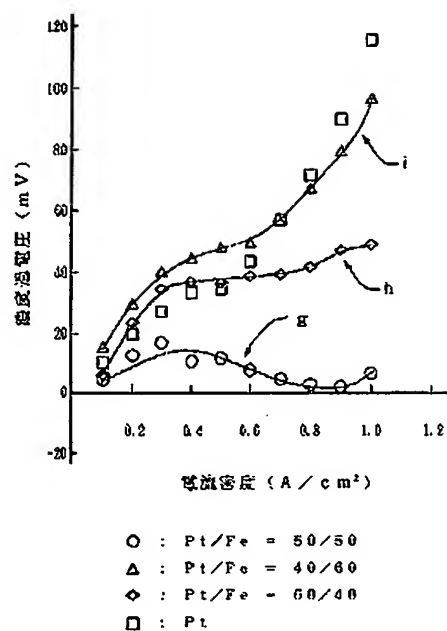
【図2】



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【図3】




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フロントページの続き

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**CLAIMS**

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[Claim(s)]

[Claim 1] The electrode catalyst characterized by including the platinum-iron alloy of \*\*\*\*\*.

[Claim 2] The electrode catalyst according to claim 1 which includes the platinum-iron alloy containing the iron of 25 - 75 atom %.

[Claim 3] The electrode catalyst according to claim 1 which includes the platinum-iron alloy containing the iron of 40 - 60 atom %.

[Claim 4] The electrode catalyst according to claim 1 which includes the platinum-iron alloy containing the iron of 45 - 55 atom %.

[Claim 5] The fuel cell using the electrode which supported the electrode catalyst according to claim 1, 2, 3, or 4.

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DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the fuel cell using the electrode which supported the electrode catalyst and this electrode catalyst which are used for the electrode of various electrolysis or a fuel cell.

[0002]

[Description of the Prior Art] In order for there to be an anode plate as an air pole which returns the cathode and the supplied oxygen as a fuel electrode for oxidizing a fuel to the electrode of a fuel cell, to promote the reaction on each of these electrodes and to raise the engine performance of a fuel cell, making each electrode support an electrode catalyst is performed.

[0003] about 1.2 as shows the I-V property (cel electrical potential difference to current density) of the fuel cell are using hydrogen as a fuel and using air (oxygen) as an oxidizer theoretically to the curve a of drawing 1 as an example -- V -- a passage -- the shape of a straight line, although it is thought that it has output characteristics It is the following (i) - (iii) the cause in fact, and as shown in this drawing curve b, it is already known that curve greatly according to the increment in current density, and the cel electrical potential difference serves as the property of falling and deteriorating. If the cause is divided roughly, it will set to drawing 1 as a thing resulting from the reaction rate of the reacting matter (hydrogen, oxygen, etc.) on the (i) electrode. Activation overvoltage  $\eta_{aa}$  shown in the amount inserted with Curve a and Curve c It sets to drawing 1 as a thing resulting from the internal resistance of the electrolyte of the loss to depend and the (ii) cell etc. Resistance overvoltage  $\eta_{ar}$  shown in the amount inserted with Curve c and Curve d It sets to drawing 1 as a thing resulting from the reacting matter to the reaction place (on the catalyst which usually exists in an electrode) on the loss to depend and an electrode (iii), or the ease of carrying out of migration of a resultant. Concentration overvoltage  $\eta_{ac}$  shown in the amount sandwiched by Curve d and Curve b Loss \*\* to depend is mentioned.

[0004]

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TECHNICAL FIELD

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[Field of the Invention] This invention relates to the fuel cell using the electrode which supported the electrode catalyst and this electrode catalyst which are used for the electrode of various electrolysis or a fuel cell.

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[Translation done.]

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## PRIOR ART

[Description of the Prior Art] In order for there to be an anode plate as an air pole which returns the cathode and the supplied oxygen as a fuel electrode for oxidizing a fuel to the electrode of a fuel cell, to promote the reaction on each of these electrodes and to raise the engine performance of a fuel cell, making each electrode support an electrode catalyst is performed.

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[0004] When a total overvoltage is set to  $\eta$  and current density is set to  $I$ , it is activation overvoltage  $\eta_{aa}$ , resistance overvoltage  $\eta_{ar}$ , and concentration overvoltage  $\eta_{ac}$ . In between, it is already reported that the following formula (1) - a formula (4) are materialized (work "basic of electrochemistry" Gihodo Shuppan issue besides Kita, the 200th page).

[0005]

[Equation 1]

$$\eta = \eta_a + \eta_r + \eta_c \quad (式1)$$

$$\eta_a = a - b \times \log I \quad (式2)$$

$$\eta_c = b \times \log \left(1 - \frac{I}{I_L}\right) \quad (式3)$$

$$\eta_r = I R \quad (式4)$$

[0006] Setting at each above-mentioned ceremony,  $a$  and  $b$  are a constant and  $I_L$ . It is the value called limiting current density, and is the constant decided by the critical mass which reacting matter or a resultant can move for a reaction. This migration critical mass changes with the structure of an electrode, the concentration (porosity, thickness, etc.) of the matter, etc., in order that reacting matter or a resultant may move by diffusion usually. Moreover,  $R$  is resistance.

[0007] As shown in a formula (4), current density  $I$  is limiting current density  $I_L$ . If it approaches, it is concentration overvoltage  $\eta_{ac}$ . It increases diffusively.

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[Translation done.]

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EFFECT OF THE INVENTION

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[Effect of the Invention] As for the fuel cell using the electrode catalyst of this invention, the fall of concentration overvoltage can control the fall of the output of a cause.

[0024] Since the electrode catalyst of this invention has the reduction effectiveness of concentration overvoltage, also in any of a fuel electrode and an air pole, the utilization factor of the fuel cell using this electrode catalyst of the hydrogen which is those reactant gas, and oxygen improves, and even when these reactant gas partial pressures in distributed gas are low, it produces sufficient output.

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TECHNICAL PROBLEM

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[Problem(s) to be Solved by the Invention] this invention persons -- concentration overvoltage etac the trouble that diffusive increase has big effect on the fall of the cel electrical potential difference of a fuel cell -- recognizing -- concentration overvoltage etac the electrode catalyst considered that there is relation -- paying one's attention -- the object for fuel cells -- high -- an activity electrode catalyst is developed and it aims at offering the fuel cell using the electrode which supported this electrode catalyst.

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MEANS

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[Means for Solving the Problem] As a result of searching wholeheartedly about various metals or the availability to the electrode catalyst of an alloy ingredient paying attention to weakening adsorption of a up to [ the catalyst of the oxygen with which it is guessed in view of the above-mentioned trouble that this invention persons are the causes of a fall of concentration overvoltage ], the platinum-iron alloy of the specific crystal structure found out that it was suitable for the electrode catalyst of a fuel cell with few increments in concentration overvoltage, and resulted in this invention.

[0010] That is, the electrode catalyst of this invention is characterized by including the platinum-iron alloy of \*\*\*\*\*. As for the platinum-iron alloy of \*\*\*\*\*, it is preferably desirable 25 to 75 atom % and that they are 40 to 60 atom % and the platinum-iron alloy which contains the iron of 45 - 55 atom % most preferably still more preferably. If iron atomic % exceeds less than 25 and 75, effect of an increment of concentration overvoltage cannot be disregarded in the fuel cell using the electrode which supported this platinum-iron alloy, and it is not desirable on the engine performance of a fuel cell.

[0011] Moreover, the fuel cell of this invention is characterized by using the electrode which supported the electrode catalyst which has the above-mentioned description.

[0012] It is important for the electrode catalyst of this invention that the gestalt of the crystal of a platinum-iron alloy is \*\*\*\*\*. If \*\*\*\*\* collapses, it is concentration overvoltage etac. The cell electrical potential difference of a cause falls [ loss ], the engine performance of a fuel cell falls, and it is not desirable.

[0013] Concentration overvoltage etac in the fuel cell by the electrode catalyst of this invention It is thought that the reduction-ized effectiveness of a fall will be what the adsorption power of the oxygen to the electrode catalyst of this invention produces since it is weak compared with the adsorption power over the conventional electrode catalyst.

[0014] Also not only in the anode plate where a reduction operation of oxygen is performed but a fuel electrode, the application as a CO-proof poisoning catalyst is possible for the electrode catalyst of this invention.

[0015] It can be used making an electrode material support the electrode catalyst of this invention, and the support approach of the electrode catalyst may form a catalyst bed with the application of the paste containing catalyst fine particles on the electrode which consists of electrode materials, such as carbon.

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[Translation done.]

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EXAMPLE

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[Example]

[Example 1] It consisted of ion-exchange resin dispersion liquid (Nafion solution: Aldrich make) and catalyst fine particles on the electrode which consists of porous carbon which \*\*\*\*\* (ed) by Teflon dispersion (the Daikin Industries, LTD. make, D-1), and the electrode (air pole) with which two kinds of catalyst beds as follows were formed in print processes with the application of two kinds of pastes with which catalyst components differ was manufactured respectively. That is, it consists only of Pt as an electrode catalyst, and the amount of Pt support is 0.3 mg/cm<sup>2</sup>. The Pt-Fe alloy of \*\*\*\*\* with which atomic ratio Pt/Fe serves as an air pole from 50/50 as an electrode catalyst is applied, and the amount of support of Pt component is 2 0.3mg/cm. The air pole was obtained.

[0017] On the other hand, the amount of Pt support is 2 0.5mg/cm like the above-mentioned air pole as a fuel electrode. The electrode was manufactured.

[0018] Two sorts of cells (cel effective area is 2 and \*\*45 20.25cm) with which the classes of electrode catalyst differ were respectively manufactured by inserting and carrying out the hotpress of the Nafion 115 film (trade name: the U.S. Du Pont make) between the air poles and fuel electrodes which were obtained at said process. Air was operated for hydrogen gas at a sink and the cell temperature of 70 degrees C to the cathode of each of this fuel cell in the anode plate, and the cel electrical potential difference to current density was measured. The result is shown in the graph of the current density-voltage characteristic of drawing 2. 50/50 and Curve f show the case where, as for Curve e, atomic ratio Pt/Fe uses Pt100% of electrode catalyst, among drawing 2, respectively.

[0019] According to drawing 2, it turns out that there is less descent of a cel electrical potential difference [ as opposed to current density in the direction when atomic ratio Pt/Fe considers as 50/50 ] than Pt100% of thing. Therefore, for example, when stationary actuation of the fuel cell is carried out by 0.6V, what the direction when atomic ratio Pt/Fe considers as 50/50 rather than Pt100% of thing can expect the increase of about 60% of output for is understood. By reduction of concentration overvoltage, potential efficiency can also improve and it can consider as an efficient fuel cell. moreover -- Pt100% of electrode catalyst -- the limiting current density of a fuel cell -- 0.86 A/cm<sup>2</sup> it was -- a thing -- receiving -- the electrode catalyst of atomic ratio Pt/Fe=50/50 of this example 1 -- 1.04 A/cm<sup>2</sup> up to -- it was able to attain.

[0020] [Example 2] Using 50/50, 40/60, and the Pt-Fe alloy of \*\*\*\*\* of 60/40 as an electrode catalyst, by the same approach as said example 1, atomic ratio Pt/Fe manufactured three kinds of electrodes with which the quality of the materials differ, and manufactured the cell respectively further. The cell was manufactured similarly, using Pt100% of electrode catalyst as an example of a comparison.

[0021] Furthermore, the cel electrical potential difference to the current density at the time of making an oxidizer into oxygen about each cell by the same approach as said example 1 was measured. It asked for concentration overvoltage from the cel electrical potential difference. The result is shown in the graph of the current density-concentration overvoltage property of drawing 3. Among drawing 3, in 50/50 and Curve h (◇ mark), atomic ratio Pt/Fe shows the electrode catalyst of 40/60 of this inventions, and, as for Curve g (O mark), atomic ratio Pt/Fe shows [ 60/40 and Curve i (\*\* mark) ] the electrode catalyst of



100/0 of the examples of a comparison, as for \*\* mark.

[0022] According to drawing 3 , it turns out that there is least descent of a cel electrical potential difference [ as opposed to current density in the case where atomic ratio Pt/Fe considers as 50/50 ].

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[Translation done.]

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**DESCRIPTION OF DRAWINGS**

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[Brief Description of the Drawings]

[Drawing 1] It is the graph which shows an example of the I-V property (cell electrical potential difference to current density) of the fuel cell are using hydrogen as a conventional fuel and using air (oxygen) as an oxidizer.

[Drawing 2] It is the graph which shows the cell electrical potential difference to the current density by the fuel cell using the electrode which supported Pt100% of electrode catalyst, and the fuel cell using the electrode which supported the Pt-Fe alloy of \*\*\*\*\* of atomic ratio Pt/Fe=50/50 as an electrode catalyst.

[Drawing 3] It is the graph which shows the property of concentration overvoltage over the current density by atomic ratio Pt/Fe=50/50, 40/60, the Pt-Fe alloy of each \*\*\*\*\* of 60/40, and the fuel cell using each electrode which supported Pt/Fe=100/0 as an electrode catalyst.

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[Translation done.]

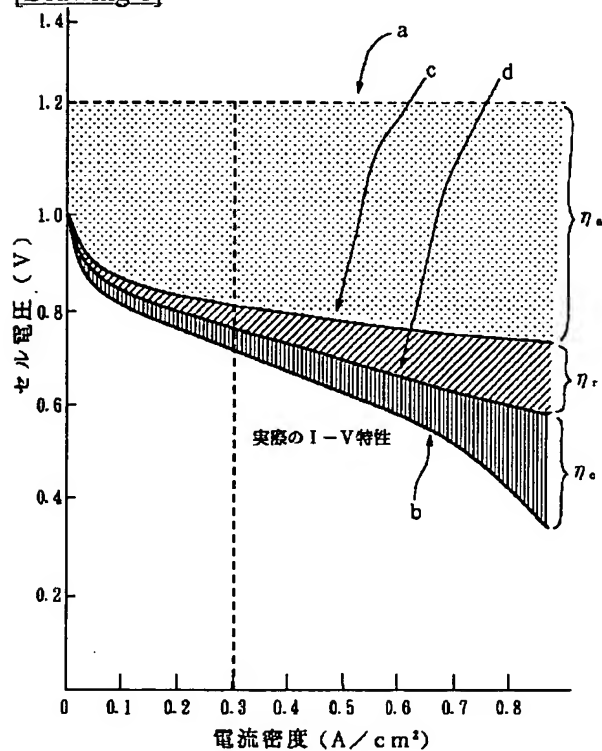
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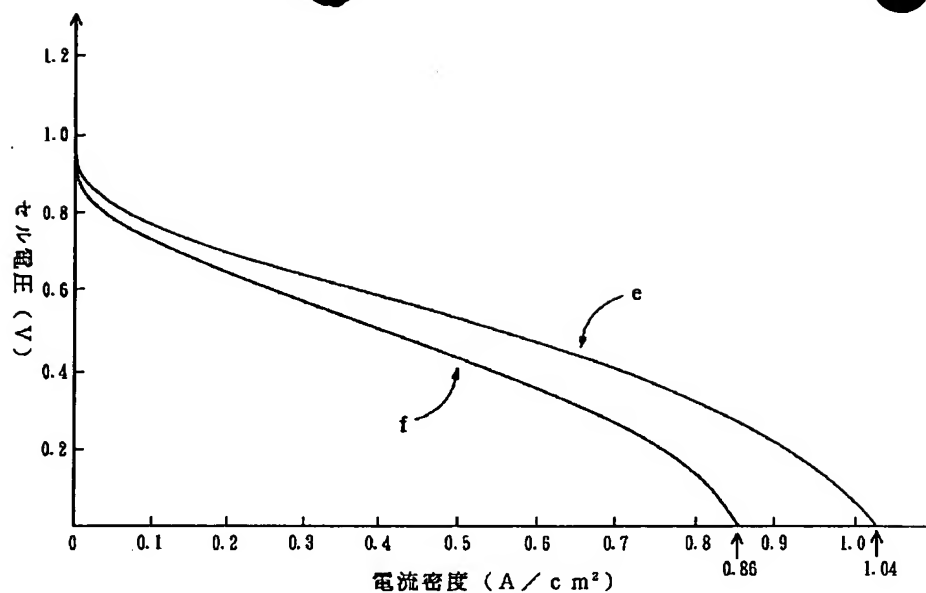
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## DRAWINGS

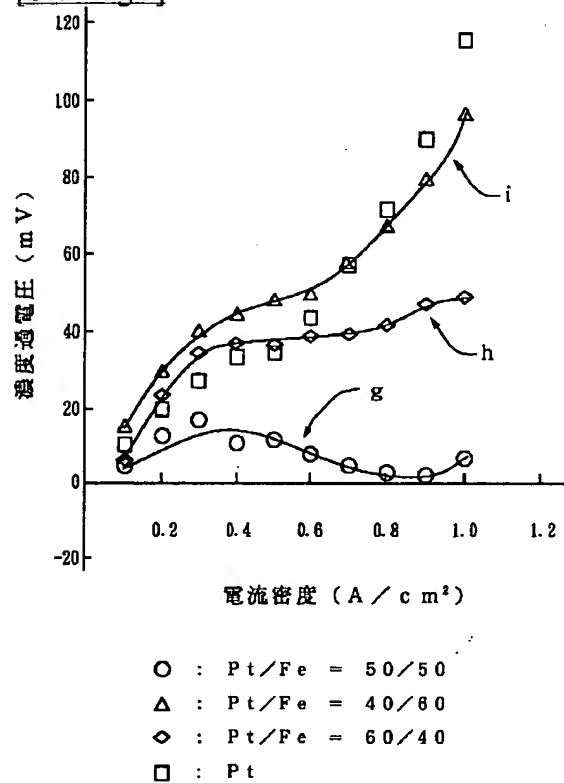
[Drawing 1]



[Drawing 2]



[Drawing 3]



[Translation done.]